

IN THE SPECIFICATION

On page 1, line 1, please add the following paragraph:

PRIORITY OF INVENTION

This non-provisional application claims the benefit of priority under 35 U.S.C. § 119(e) to U.S. Provisional Patent Application Serial No. 60/476,404, filed on June 6, 2003, which is herein incorporated by reference.

On page 6, line 24, please amend the paragraph as follows:

The invention also contemplates that the curable liquid electrolyte solution can further comprise an elastising elasticizing agent. The elasticizing agent can be a polymerizable vinyl monomer to enhance the toughness of structure of the cured electrolyte.

On page 11, line 13, please amend the paragraph as follows:

The method can also include the step of adding a solvent to the mixture or adding an elastising elasticizing agent to the mixture for the electrolyte. An example of an elasticizing agent is a polymerizable vinyl monomer to enhance the toughness of structure of the cured protonic polymer electrolyte.

On page 17, line 15, please amend the paragraph as follows:

In another embodiment, a photo-curable recast Nafion™ electrolyte composed of 30% Nafion 117 and 70% monomer mixture (15:65:20 ratio of vinyl phosphoric acid, divinyl sulfone, and acrylonitrile acrylonitrile) was prepared. The 5% Nafion™ 117 solution was mixed with a monomer mixture of vinyl phosphoric acid (300 mg) and divinyl sulfone (1300 mg) in the presence of a photoinitiator (75 mg) and N, N-dimethylacetamide (500 mg). After the removal of the original solvent, acrylonitrile (400 mg) was added. A membrane was prepared by casting

a liquid layer on a glass slide forming a film and curing with a visible light for four hours. The membrane was annealed on the glass slide between 140 degrees Celsius and 150 degrees Celsius for 4 hours in a nitrogen atmosphere. A strong and flexible recast Nafion™ membrane was freed from the glass by soaking with deionized water. This membrane shows excellent stability in boiling water with a water uptake of 31% at room temperature.

On page 13, lines 16-18, please amend the paragraph as follows:

Liquid electrolyte was prepared by dissolution of S-PEEK in a vinyl monomer mixture in the absence or presence of a photo-initiator or a photo-initiating system. Generally, vinyl monomers mixtures consist of a protonic monomer, vinyl phosphoric phosphonic acid protonic monomer, a divinyl sulfone cross-linking agent divinyl sulfone, and a third monomer acrylonitrile. In some cases, water and or an organic compound, N, N-dimethylacetamide, (DMA) can be added. The liquid electrolyte was cured by photo or electro beam (EB) exposure.

On page 11, line 28, please amend the paragraph as follows:

Figure 1 shows a cross section of a conventional electrochemical cell in which a solid polymer electrolyte sheet (10) is bonded to a pair of catalyzed gas diffusion electrodes (20 and 30). The assembly that results is known as a membrane electrode assembly (MEA) (40). The MEA (40) is then clamped between flow plates (50 and 60) to form a working electrochemical cell (70), in this case a fuel cell. In this example, pre-formed electrolyte sheets (10) interface between the electrolyte (10) and the electrodes (20 and 30) and rely on the mechanical bonding of the discrete components. Variations in the approach to manufacturing cells this way are used, but most continue to rely upon the mechanical bonding of the discrete MEA components. The present invention ~~does not uses~~ ionic bonding[[,]] rather than mechanical bonding[[,]].

On page 13, line 23, please amend the paragraph as follows:

A second example of a photo-curable liquid electrolyte uses 30% wt/wt S-PEEK (71%

sulfonation) and 70% monomer mixture (22.5% vinyl phosphoric phosphonic acid, 52.5% divinyl sulfone, and 25% acrylonitrile of the mixture) in the presence of 3.75% photo-initiator of monomers was formed with good mechanical properties and good proton conductivity usable for a fuel cell or other electrochemical cell..

On page 13, line 28, please amend the paragraph as follows:

This electrolyte used S-PEEK (865 mg) dissolved in 2000 mg monomer mixture composing of vinyl phosphoric phosphonic acid (450 mg), divinyl sulfone (1050 mg), and acrylonitrile (500 mg) in the presence of a photo initiator (75 mg). An electrolyte membrane was prepared by casting the resultant liquid electrolyte on a glass slide and exposing the film to visible light for four hours. The membrane was freed from the slide by soaking with water. Proton conductivity was 0.058 S/cm at room temperature and 100% humidity. The conductivity measurement was made with an impedance analyzer.

On page 14, line 8, please amend the paragraph as follows:

An electron beam curable liquid electrolyte composed of 30% wt/wt S-PEEK (58% sulfonation) and 70% monomer mixture (15% vinyl phosphoric phosphonic acid, 55% divinyl sulfone, and 30% methylacrylonitrile of the mixture) in the presence of 12.2% of N, N-dimethylacetamide was made.

On page 14, line 11, please amend the paragraph as follows:

Another example of a curable electrolyte is S-PEEK (865 mg) dissolved in 2000 mg monomer mixture comprised of vinyl phosphoric phosphonic acid (300 mg), divinyl sulfone (1100mg), and methylacrylonitrile (600 mg). An electrolyte membrane from this mixture was prepared by casting the resultant liquid electrolyte on a glass slide forming a film and exposing the electrolyte to a electron beam with a dose of about 250 KGy. The proton conductivity of the membrane is 0.060 S/cm at room temperature with 100% humidity.

Serial Number: 10/781,363

Filing Date: February 18, 2004

Title: ELECTROCHEMICAL CELL AND FUEL CELL WITH CURABLE LIQUID ELECTROLYTE

On page 14, line 21, please amend the paragraph as follows:

In a preferred cell, small voids can be formed directly within the liquid electrolyte that acts as a water reservoir to aid in humidification of the cured membrane. These voids are formed by including a high boiling point organic compound within the liquid electrolyte mixture. A liquid electrolyte composing 30% wt/wt S-PEEK (63% sulfonation) and 70% monomer mixture (15 vinyl phosphoric phosphonic acid, 45% divinyl sulfone, and 30% acrylonitrile of the mixture) in the presence of 20% of N, N-dimethylacetamide was usable.

On page 14, line 25, please amend the paragraph as follows:

In still another example, S-PEEK (865 mg) was dissolved in 2000 mg monomer mixture composing of vinyl phosphoric phosphonic acid (300 mg), divinyl sulfone (900 mg), and acrylonitrile (800 mg) in the presence of a photoinitiator (75 mg) and N, N-dimethylacetamide (567 mg). An electrolyte membrane was prepared by casting the resulting liquid electrolyte on a glass slide and exposing the film to visible light for 4 hours. Nano-voids were created by removal of N, N-dimethylacetamide under vacuum at room temperature.

On page 15, lines 8 and 12, please amend the paragraph as follows:

In still another embodiment, water is included within the liquid mixture described above so that after curing a pre-hydrated membrane is formed. The pre-hydrated membrane preferable made from a liquid electrolyte composed of S-PEEK (71% sulfonation) and a monomer mixture (22.5% vinyl phosphoric phosphonic acid, 52.5% divinyl sulfone, and 25% acrylonitrile of the mixture) in the presence of water. For this example, S-PEEK (865 mg) was dissolved in 2000 mg monomer mixture composed of vinyl phosphoric phosphonic acid (450 mg), divinyl sulfone (1050 mg), and acrylonitrile (500 mg) in the presence of a photoinitiator (75 mg) and water (600 mg). An electrolyte membrane was prepared by casting the resultant liquid electrolyte on a glass slide forming a film and exposing the film to visible light for three hours. The proton conductivity of the membrane was measured at 0.060 S/cm at room temperature with 100% humidity.

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On page 15, line 21, please amend the paragraph as follows:

Figure 5 shows a table of performance data indicating that the conductivity of the cured electrolyte can be controlled by controlling the sulfonation level of the SPEEK as previously described. The figure provides measured results for 3 liquid electrolytes composing 30% wt S-PEEK with different sulfonation levels and 70% monomer mixture (15 vinyl phosphoric phosphonic acid, 42.5% divinyl sulfone, and 42.5% acrylonitrile) in the presence of 2.6% photoinitiator and 20% of N, N-dimethylacetamide.

On page 15, line 25, please amend the paragraph as follows:

For these examples, S-PEEK (865 mg) was dissolved in 2000 mg monomer mixture composed of vinyl phosphoric phosphonic acid (300 mg), divinyl sulfone (850 mg), and acrylonitrile (850 mg) in the presence of a photo initiator (75 mg) and N, N-dimethylacetamide (567 mg). Electrolyte membranes were prepared by casting the resultant liquid electrolytes on glass slides forming a film and exposing the films to visible light for four hours. The proton conductivity of those membranes at room temperature with 100% humidity is shown in Figure 5.

On page 16, lines 5 and 7, please amend the paragraph as follows:

The conductivity and the amount of water uptake of the electrolyte can be controlled by controlling the degree of cross-linking when the curable liquid electrolyte is cured. A liquid electrolyte which has the composition of 30% S-PEEK (63% sulfonation) and 70% monomer mixture (30:62.5:22.5 ratio of vinyl phosphoric phosphonic acid, divinyl sulfone, and acrylonitrile) can be usable. This electrolyte forms S-PEEK (865 mg) dissolved in a monomer mixture (200 mg) composing of vinyl phosphoric phosphonic acid (300 mg), divinyl sulfone (850 mg), and acrylonitrile (850 mg) in the presence of a photo initiator (75 mg) and N, N-dimethylacetamide (567 mg). Electrolyte membranes were prepared by casting the resultant liquid electrolyte on glass slides forming a film and exposing them to visible light for four hours. The resultant membrane showed high mechanical strength and high stability in water due to the high degree of cross-linking resulting from the large amount of divinyl sulfone used in the

mixture.

On page 16, line 20, please amend the paragraph as follows:

Conductivity and water uptake are also controllable by controlling the degree of polymerization. A liquid electrolyte composing of 70% S-PEEK (58% sulfonation) and 70% monomer mixture (30:62.5:22.5 ratio of vinyl phosphoric phosphonic acid, divinyl sulfone, and acrylonitrile) with 14% of N, N-dimethylacetamide was cured by electron beam with different doses to control the degree of polymerization of monomers.

On page 16, line 25, please amend the paragraph as follows:

For this version. S-PEEK (865 mg) was dissolved in a monomer mixture (200 mg) composing of vinyl phosphoric phosphonic acid (300 mg), divinyl sulfone (1300 [[g]] mg), and acrylonitrile (400 mg) in the presence of N, N-dimethylacetamide (400 mg). Electrolyte membranes were prepared by casting the resultant liquid electrolyte on a glass slide forming a film and exposing to an electron beam with doses varying form 150 KGy to 350 KGy.

On page 17, lines 6-7 and 8, please amend the paragraph as follows:

A curable recast NafionTM electrolyte was prepared by exchanging the original solvents in 5% NafionTM [[117]] solution with vinyl monomers. NafionTM solution was added to a vinyl monomer mixture in the absence or presence of a photo initiator or a photo initiating system. The vinyl monomer mixture consisted of ~~a protic monomer~~, a vinyl phosphoric phosphonic acid protic monomer, ~~and a divinyl sulfone~~ [[a]] cross-linking agent, ~~and a divinyl sulfone~~. A high boiling point organic solvent, N, N-dimethylacetamide, (DMA) may be added for enhanced annealing of the cured electrolytes. The original solvents of the NafionTM solution were removed by soft vacuum distillation using a rotary evaporator to give a photo-curable or electron-beam-curable liquid electrolyte. Cured electrolytes were annealed between 140 degrees Celsius and 160 degrees Celsius to improve their mechanical strength and solvent resistance.

On page 17, lines 16 and 18, please amend the paragraph as follows:

In another embodiment, a photo-curable recast NafionTM electrolyte composed of 30%

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Nafion [[117]] and 70% monomer mixture (15:65:20 ratio of vinyl phosphoric phosphonic acid, divinyl sulfone, and acrylonitril) was prepared. The 5% NafionTM [[117]] solution was mixed with a monomer mixture of vinyl phosphoric phosphonic acid (300 mg) and divinyl sulfone (1300 mg) in the presence of a photoinitiator (75 mg) and N, N-dimethylacetamide (500 mg). After the removal of the original solvent, acrylonitrile (400 mg) was added. A membrane was prepared by casting a liquid layer on a glass slide forming a film and curing with a visible light for four hours. The membrane was annealed on the glass slide between 140 degrees Celsius and 150 degrees Celsius for 4 hours in a nitrogen atmosphere. A strong and flexible recast NafionTM membrane was freed from the glass by soaking with deionized water. This membrane shows excellent stability in boiling water with a water uptake of 31% at room temperature.

On page 17, line 30, and on page 18, lines 1 and 3, please amend the paragraph as follows:

In an alternate embodiment, an electron-beam curable recast NafionTM electrolyte was formed composed of 30% NafionTM [[117]] and 70% monomer mixture (15:55:30 ratio of vinyl phosphoric phosphonic acid, divinyl sulfone, and methylacrylonitrile) in the presence of N, N-dimethylacetamide. The 5% NafionTM [[117]] solution was mixed with a monomer mixture of vinyl phosphoric phosphonic acid (300 mg) and divinyl sulfone (1100 mg) in the presence of N, N-dimethylacetamide (500 mg). After the removal of the original solvents, methylacrylonitrile (600 mg) was added. A membrane was prepared by casting a liquid layer of the electrolyte on a glass slide and curing with electron beam (EB) at doses of about 100 KGy. The membrane was annealed on the glass slide between 140 degrees Celsius and 150 degrees Celsius for four hours in a nitrogen atmosphere. The proton conductivity of the cured membrane is 0.031 at room temperature.

On page 18, lines 13-16, please amend the paragraph as follows:

The conductivity of the recast Nation liquid electrolytes can be controlled by controlling the degree of cross-linking. A curable recast NafionTM electron composed of 30% NafionTM

[[117]] and 70% monomer mixture (15:42.5:42.5 ratio of vinyl phosphoric acid, divinyl sulfone, and acrylonitrile) was prepared with a lower degree of cross-linking than the original recast Nafion™ example. Nafion™ [[117]] solution was mixed with a monomer mixture of vinyl phosphoric acid (300 mg) and divinyl sulfone (850 mg) in the presence of a photo initiator (75 mg) and N, N-dimethylacetamide (500 mg). After the removal of the original solvents, a third monomer, acrylonitrile (850 mg) was added. A membrane was prepared by casting a liquid layer on a glass slide and curing with visible light for four hours. The membrane was annealed on the glass slide between 140 degrees Celsius and 150 degrees Celsius for four hours in a nitrogen atmosphere.